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CONTENT

AGRICULTURAL SCIENCES

EARTH SCIENCES

TECHNICAL SCIENCES

Выводы и перспективы исследований. На основании исследований автора разработаны и рассчитаны различные динамические схемы для вариантов подвесных и консольных сооружений. На примере конструкции водонапорной башни показано, что подвесное сооружение оказывается эффективнее сооружения, работающего по традиционной консольной схеме. Показано, что на динамические усилия оказывают существенное влияние жесткость несущего каркаса в горизонтальном направлении, длина нити подвеса, а также амплитуда и частота колебания основания.

Исследования показали весьма малую эффективность варианта сооружения с подвесным фундаментом, т.к. динамические усилия в его несущих элементах оказываются значительно большими как усилий в подвесном варианте, так и усилий в консольном (традиционном) варианте.

В перспективе планируется дальнейшее совершенствование конструкции подвесных зданий и сооружений с целью уменьшения перемещений подвесного сооружения при колебаниях земной поверхности.

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MICROPROCESSOR-BASED SYSTEM OF THE ENERGY TRANSMISSION PROCESS OPTIMIZATION BY PHOTOVOLTAIC POWER PLANTS IN THE GRID

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ABSTRACT

Microprocessor control system, based on mathematical optimization model, applying fuzzy sets tools was developed. Microprocessor optimization system is provided to combine intelligent control unit, operator workstation, local meteostation and smart grid invertor. Data exchange was carried out by the standard protocols and data transfer interfaces. Intelligent control unit is suggested to realize on the base of the microcontroller PIC32MZ, manufactured by microchip company, on the base of the core MIPS microAptiv UP. The concept of control is the following: intelligent unit colects the information from the local meteostation, regarding the temperature, amount of solar radiation and air humidity. From the Smart grid the intelligent unit obtains the data concerning the voltage level. As a result of processing the obtained information control unit sends the control signal to the inverter of the photovoltaic power plant and sends the necessary information to the operator workstation.

The paper contains the developed circuit diagram and element base, the algorithm of he intelligent unit of microprocessor optimization system operation according to mathematical optimization model, using fuzzy sets tool. As the system is realized on modern element base, this enables to integrate it easily in the existing control systems of photovoltaic power plants and Smart grid systems. The application of the proposed system will enable to improve the efficiency of electric energy transmission by the photovoltaic power plants in the grid and will provide the maintaining of the balance stability of energy system.

Keywords: microprocessor control system, photovoltaic power plant, algorithm, mathematical optimization model.

Problem set up

The growth of specific consumption per person, originated energy deficit inclusive, in it's turn, this resulted to the increase of loading on electric grids, stimulates the increase of generation capacifies, in particular, rapid development of renewable sources of energy, both in the world and in Ukraine although the requirements to the grids continue to grow, there are no physical and financial resources.

On the contrary, the budgets became more rigid and norms and social problems limit the range of the real variants. Nevertheless, the quality of electric energy must improve and the grids must be adjusted according to new requirements, caused by the growth of the decentralized generation and more complex loading control. When referring to the transmission of the alternating current, the emphasis is made on the stability of the grid at all the levels of the voltage.

Taking into account that RSE, in particular, photovoltaic power plants, are characterized by the non-stability of the generation power(daily, meteorological, etc), distribution by electrical grids and other characteristics, which do not allow to integrate these sources in the existing grids without certain changes in the organization and maintenance of energy facilities, the problem of optimization of their operation as a result of implementation of intelligent control technologies.

Analysis of the previous research

In [1, p. 108] the author proposed the microprocessor – based device of the control system of the network multilevel voltage inverter with the account of the limitation of the transformer magnetizing current. Also, as the author states, the control system takes into consideration the level of insolation and the temperature of the working surface of the solar module. Algorithm of microprocessor device operation was suggested but the author did not consider the operation of the device in the system in general. The operation of a separate unit, that operates without the connection of the solar plant with electric grid, where, as it is known, the general concept of the control via smart grids and dispatching systems ACKOE are realized, it is basically important for creation of the similar devices. In the process of the device realization it is not sufficient to take into account only the temperature and insolation of the solar module. Such problem needs complex consideration taking into consideration a number of climatic factors and parameters, influencing the efficiency of photo panels of the power plant on the whole. It is worth mentioning that such parameters as the air temperature and insolation in the similar systems are expressed implicitly, that is why, their processing must be performed in accordance with other approaches and algorithms, which will take into account the above-mentioned. In [2, p. 72] the control system of the solar modules converters on the base of the invertor with PWM is suggested. The authors describe the realization of the device for monitoring of the maximum power point on the base of the method of growing conductivity, is suggested. The paper considers the functional structure of the device and the algorithm of its operation, but taking into account the fact that the device is realized on the base of the analog elements, makes it less flexible for the adjustment and integration in the existing control systems of the inverter and solar power plant on the whole. Considerable amount of the research is devoted to the development of the methods of maximum power point monitoring [3, p.3, 4, p.1789, 5, p.2007, 6, p.62, 7, p.1458]. Such methods, using microprocessors with the corresponding algorithms, are characterized by the flexibility and compatibility with various photoelectric arrays. Although the efficiency of the proposed algorithms is rather high, it considerably decreases in rase of rapidly changing atmospheric conditions [8, p. 110].

Aim of the research

The aim of the research is the enhancement of the efficiency of photovoltaic power plants usage at the expense of realization of microprocessor-based control system on the base of mathematical optimization model using fuzzy sets tools.

Materials of the research

The development of microprocessor engineering created the possibility for using fuzzy logic in the problems of determination of the solar module maximum power takeoff point [9, p.1124, 10, p.965, 11, p.169, 12, p.175, 13, p.1148]. Fuzzy logic controllers have the advantages of operating with fuzzy processes, which require exact mathematical model and processing and which are characterized by their nonlinearity. In [14, p.30] mathematical model of electric energy transfer process in the grid by solar photovoltaic power plants optimization is suggested.

According to the optimization criterion of the provision of maximum electric energy supply by the controlled sources (1), fuzzy logic equations of the model of weight coefficient determining were formulated on the base of the linguistic assessment (2).

$$\int_{t_0}^{t_k} \text{ц}(t)\text{k}_{\text{тр}} \sum_{i=1}^{n} P_i(t)dt \to \max, \tag{1}$$

where $[t_0; t_k]$ – time interval, ц(t) – multislage tariff of the energy market; $k_{тр}$ –coefficient, that takes into account the decrease of the profit for RES at the expense of compensation of transportation losses in the grids, n – number of the controlled RES, $P_i(t)$ – power of the controlled energy sources.

$$\begin{aligned}
&\mu^{y1}(y)=[(\mu^{B}(x_1)\cdot\mu^{H}(x_2)\cdot\mu^{H}(x_3)\cdot\mu^{B}(x_4)\cdot\mu^{B}(x_5)\cdot\mu^{B}(x_6))\vee\\
&(\mu^{C}(x_1)\cdot\mu^{H}(x_2)\cdot\mu^{H}(x_3)\cdot\mu^{B}(x_4)\cdot\mu^{B}(x_5)\cdot\mu^{B}(x_6))\vee\\
&(\mu^{H}(x_1)\cdot\mu^{H}(x_2)\cdot\mu^{H}(x_3)\cdot\mu^{B}(x_4)\cdot\mu^{B}(x_5)\cdot\mu^{B}(x_6))\vee\\
&(\mu^{B}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{B}(x_6))\vee\\
&(\mu^{C}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{B}(x_6))\vee\\
&(\mu^{H}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{B}(x_6))\vee\\
&(\mu^{B}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{B}(x_6))].
\end{aligned} \tag{2}$$

$$\begin{aligned}
&\mu^{y2}(y)=[(\mu^{H}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{H}(x_5)\cdot\mu^{C}(x_6))\vee\\
&(\mu^{C}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{H}(x_5)\cdot\mu^{C}(x_6))\vee\\
&(\mu^{H}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{H}(x_5)\cdot\mu^{C}(x_6))\vee\\
&(\mu^{H}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{H}(x_5)\cdot\mu^{C}(x_6))\vee\\
&(\mu^{C}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{C}(x_6))\vee\\
&(\mu^{H}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{C}(x_6))\vee\\
&(\mu^{B}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{B}(x_6))\vee\\
&(\mu^{B}(x_1)\cdot\mu^{H}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{B}(x_6))].
\end{aligned}$$

$$\begin{aligned}
&\mu^{y3}(y)=[(\mu^{H}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{H}(x_5)\cdot\mu^{H}(x_6))\vee\\
&(\mu^{H}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{H}(x_6))\vee\\
&(\mu^{H}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{H}(x_4)\cdot\mu^{H}(x_5)\cdot\mu^{H}(x_6))\vee\\
&(\mu^{C}(x_1)\cdot\mu^{B}(x_2)\cdot\mu^{B}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{H}(x_6))\vee\\
&(\mu^{C}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{C}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{H}(x_6))\vee\\
&(\mu^{B}(x_1)\cdot\mu^{H}(x_2)\cdot\mu^{H}(x_3)\cdot\mu^{B}(x_4)\cdot\mu^{B}(x_5)\cdot\mu^{H}(x_6))\vee\\
&(\mu^{C}(x_1)\cdot\mu^{C}(x_2)\cdot\mu^{H}(x_3)\cdot\mu^{C}(x_4)\cdot\mu^{C}(x_5)\cdot\mu^{H}(x_6))\vee\\
&(\mu^{B}(x_1)\cdot\mu^{H}(x_2)\cdot\mu^{H}(x_3)\cdot\mu^{B}(x_4)\cdot\mu^{B}(x_5)\cdot\mu^{H}(x_6))].
\end{aligned}$$

The suggested mathematical optimization model of electric energy transmission in the grid by the solar photovoltaic power plants, using fuzzy logic tools enables to take into account climatic conditions that is decisive in the process of energy generation, especially in case of rapidly changing weather conditions.

Structural diagram of the system of regulation of energy transfer in the grid is shown in Fig 1.

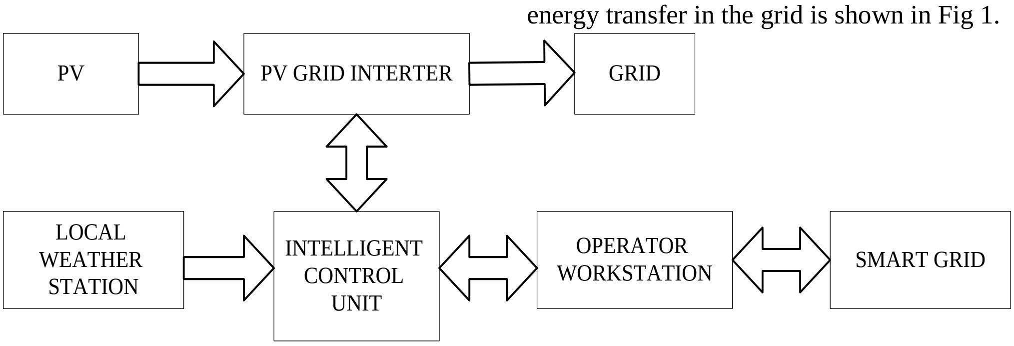

Fig 1 – Structural diagram of the regulation system of energy transmission in the grid

Structural diagram of the intelligent control unit is shown in Fig 2.

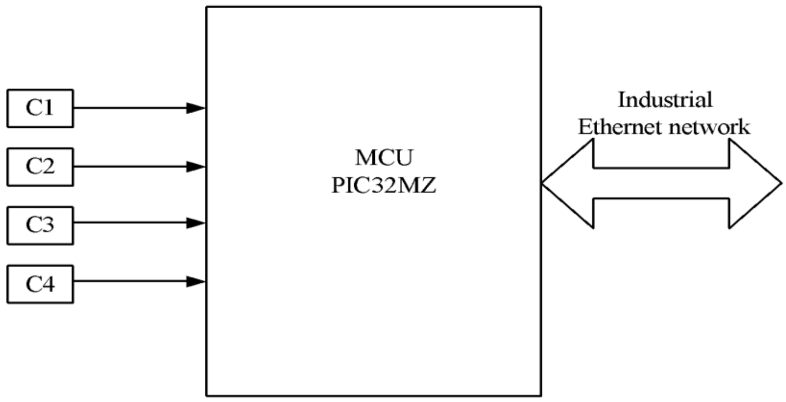

Fig 2 – Structural diagram of the intelligent control unit

C1 – sensor for measurement of the relative humidity, C2 – sensor for measurement of the intensity of solar radiation, C3 – sensor for measurement of the ambient temperature, C4 – sensor for measurement of the voltage level at the buses of photovoltaic power plant, MCU PIC32MZ – microcontroller, Industrial Ethernet network.

Intelligent control unit is build on the base of Microchip company microcontroller PIC32MZ, on the base of the core MIPS microAptiv UP [15, p.24].

Taking into account the fact, that not all meteodata can be obtained with the preset frequency of updating from Smart Grid system [16, p.28], the realization of the intelligent control unit provides the installation of the sensor of temperature, humidity, solar radiation and voltage on place. Duration of the light day and solar elevation angle is proposed to determine by means of real time click of the microcontroller and it`s synchronization with Ethernet network. Dust content of photo panels is suggested to determine, proceeding from the considerations that the voltage in d.c. circuit decreased, although the ratio of all the climatic parameters remains constant. Also it is provided to use in the circuit the sensors of grid voltage and d. c. circuit of the grid inverter. As a result of the calculation of the regulation factor by the fuzzy algorithm the signal is sent vin the industrial network Ethernet to the grid inverter, which supports the standard interface and data exchange protocol, the information, concerning the collected meteo data and the level of dust content is sent to the operator work station. And is shown in dispatching systems and systems of the automation of technological process.

As a result electrical diagram of the intelligent control unit was developed, it is shown in Fig 3.

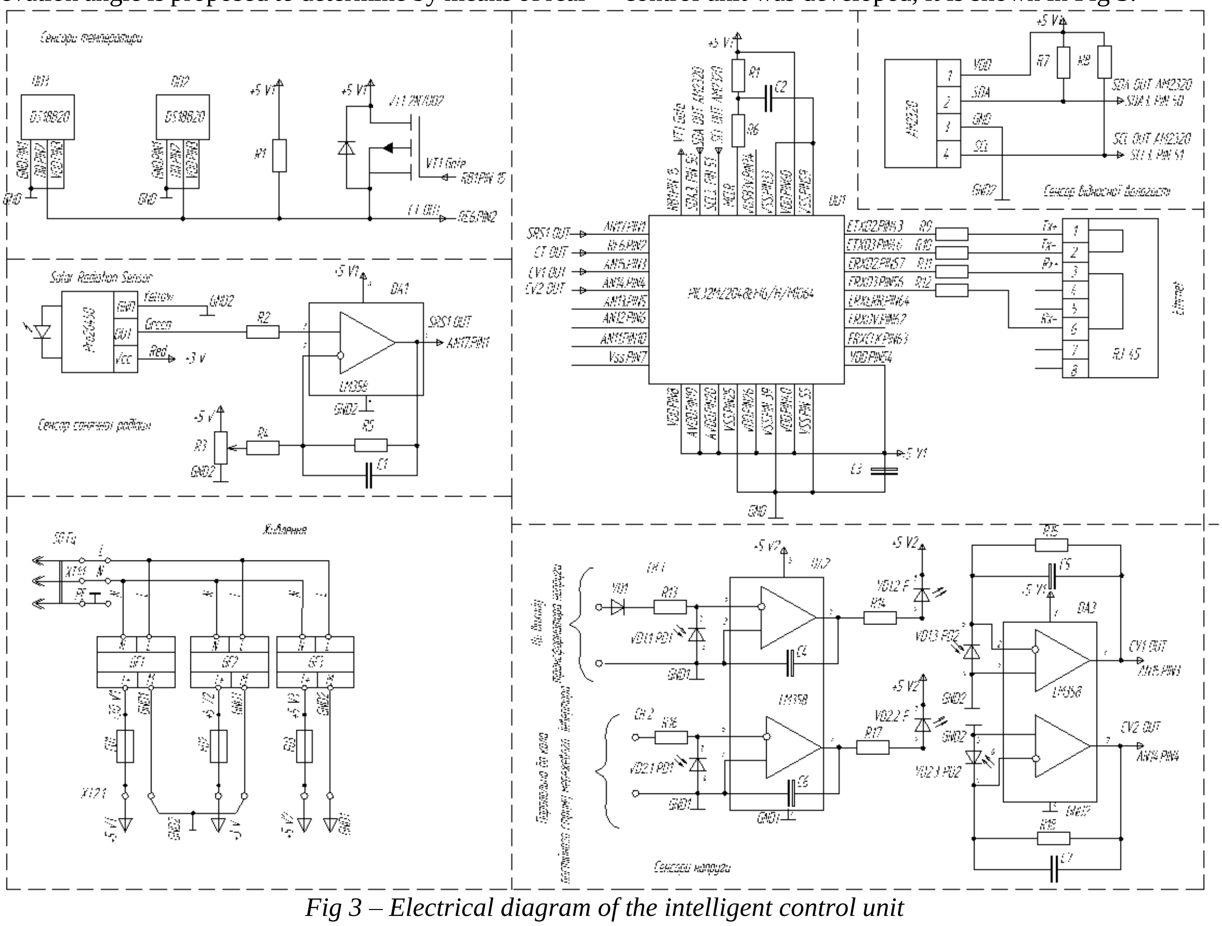

Fig 3 – Electrical diagram of the intelligent control unit

As the temperature sensor digital sensor DS18B20 of Texas Instruments with the conversion factor 9-12 digits and alarm signal of temperature control function was chosen. Sensor DS18B20 exchanges data with the microcontroller by a single wire communication line, without using the external source. Range of the temperature measurement is -55 + 125° C. For the range of -10 to +85° C the error does not exceed 0,5° C. In each microcircuit of DS18B20 there is a unique serial code, 64 digits of the length, it enables to connect several sensors to one common communication line. That is across one part the microcontroller the data exchange can be realized with several sensors, distributed at a large distance.

For the humidity measurement sensor AM320, manufactured by AOSONG company, is used. The given sensor is characterized by high stability and energy efficiency. The connection to the microcontroller is realized by means of I2C interface.

For measurement of the solar radiation Solar Radiation Sensor Pro2 6450 was selected. The given sensor measures the global value of the radiation, it is characterized high accuracy and operation rate. The connection of the solar radiation sensor to ANC of microcontroller is realized via the operation amplifier, gain factor is determined by the resistances in the direct contour and feedback contour.

Measurement of the grid voltage is realized by means of usage of the galvanic microcircuits, connected directly to the output of measuring transformer and in the d. c. circuit of the grid inverter – via the voltage divider.

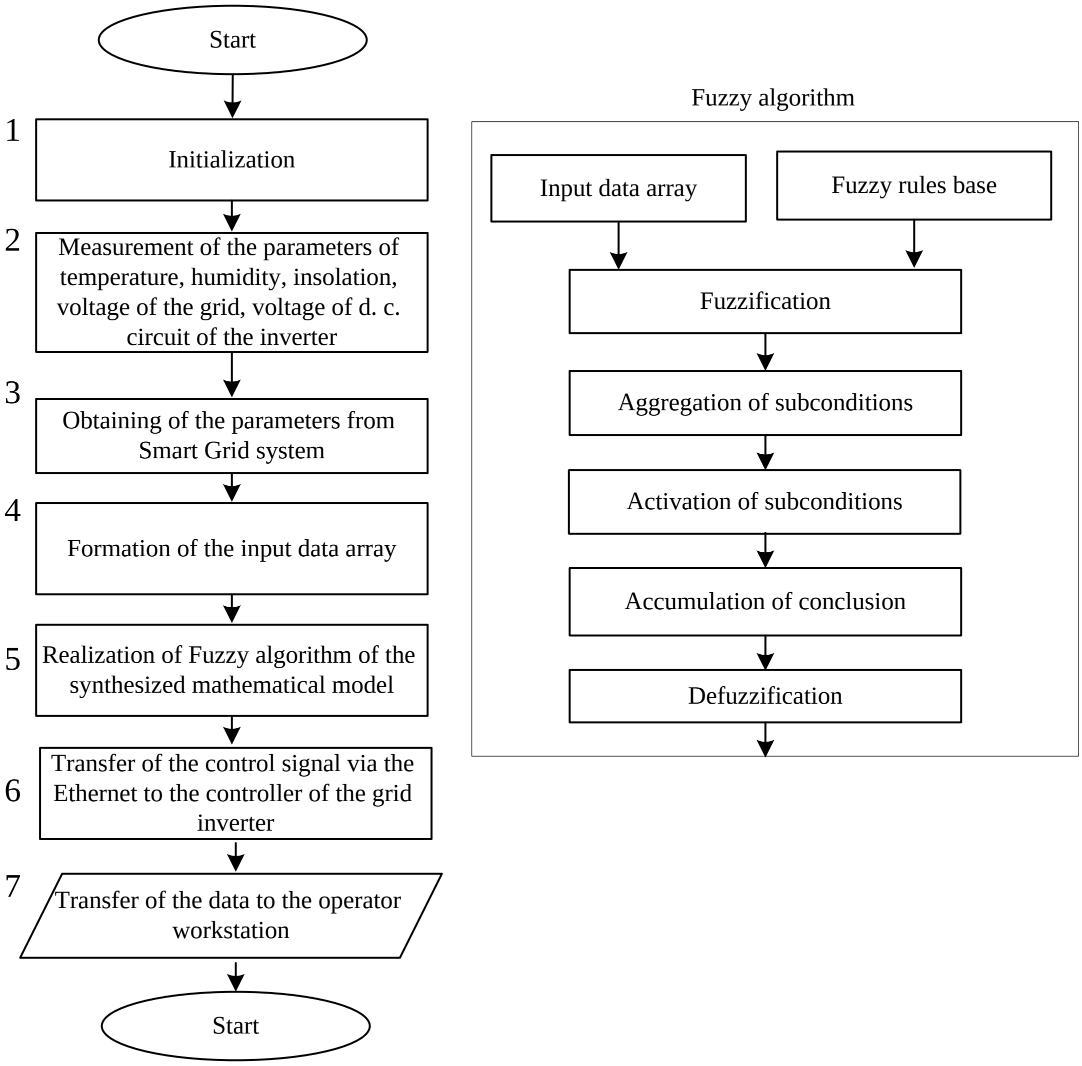

Fig 4 – General algorithm of the intelligent control unit operation and subalgorithm of fuzzy signals processing operation

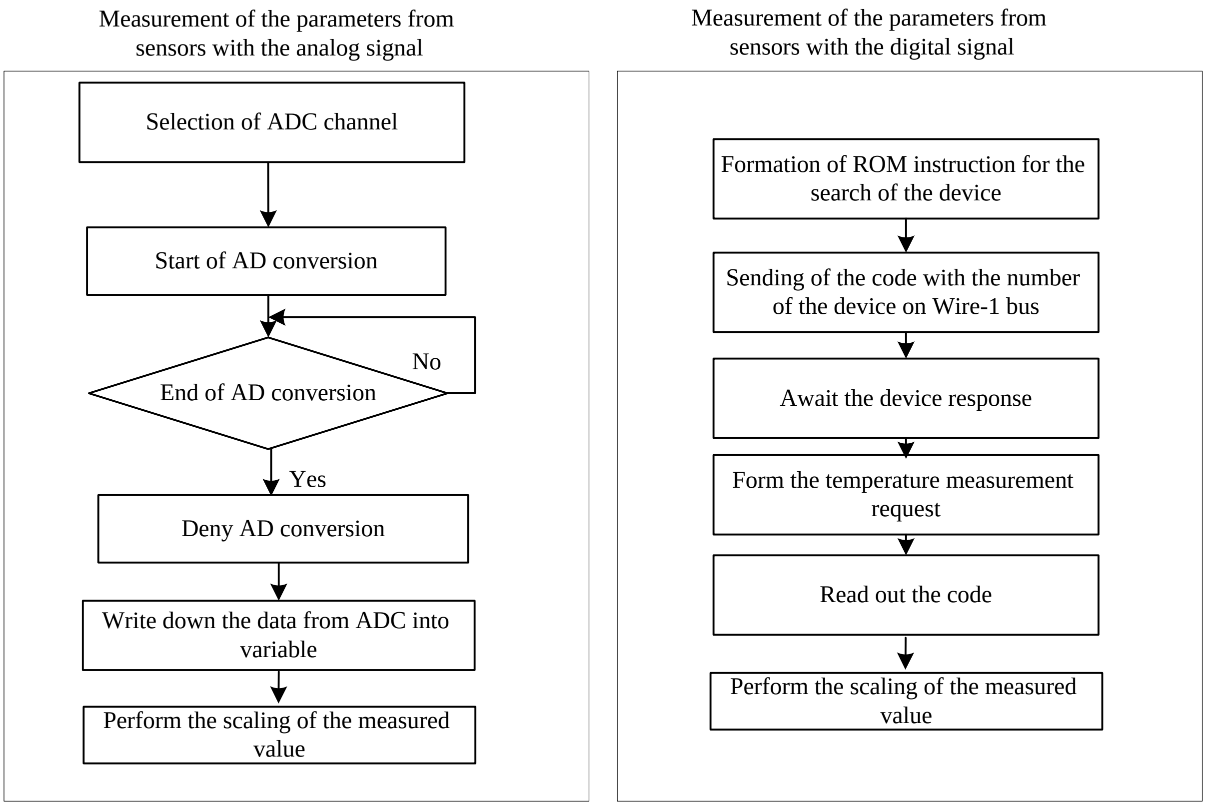

Fig 5 – Parameters measurement from the sensors

Conclusions

Microprocessor device, intended for the realization of the optimization system of the energy transmission process by photovoltaic power plants in the grid is proposed. The synthesis of the hardware and software, necessary for the realization of the microprocessor device is performed. Taking into account the complexity of the information processing, the selection of modern microprocessor base, namely microcontroller PIC32MZ for the solution of this problem was carried out. The given type of the microprocessor, are to well developed periphery, enables to integrate this device into the general system Smart Grid and provides sufficient operation rate in the process of it`s operation.

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ИСТОКИ ФЕНОМЕНОЛОГИИ В ФИЗИКЕ

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ORIGINS OF PHENOMENOLOGY IN PHYSICS

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АННОТАЦИЯ
В современном познании природы, в том числе и в физике, широко применяется феноменологический метод. Это когда при изучении объекта исследователь использует только внешнее его описание, не проникая в самую сущность внутренней структуры, в причину происходящего в нем явления. Эта особенность в познании приводит к описанию исследуемого объекта функциями, зависящими от пространства и времени, т.е. не от материальной субстанции. В работе раскрываются гносеологические корни этого метода, и приводятся примеры, в которых функции, моделирующие материальный объект, зависят от материальной субстанции.

ABSTRACT
In modern knowledge of nature, including physics, the phenomenological method is widely used. This is when, when studying an object, the researcher uses only its external description, without penetrating into the very essence of the internal structure, into the cause of the phenomenon occurring in it. This feature in cognition leads to the description of the object under study by functions depending on space and time, i.e. not from material substance. The work reveals the epistemological roots of this method, and provides examples in which the functions that simulate a material object depend on the material substance.

Ключевые слова: феноменология, математика, физика, метод «черного ящика», энергия, масса, силовая линия поля
Keywords: phenomenology, mathematics, physics, black box method, energy, mass, field line

Введение

Математика в естественной науке призвана отвечать за наиболее развитый метод абстрагирования, применение которого неразрывно связано с проблемой поиска математических функций, адекватно отображающих в природе материальные структуры и явления. Следует заметить, что эту проблему, далеко не всегда, удается разрешить. Например, формула И.Ньютона, описывающая зависимость силы взаимодействия двух тел от расстояния между ними, для различного внешнего окружения требует своего уточнения, которое, обычно, осуществляется корректировкой постоянной гравитации. Известно, что сила земного тяготения в космосе не совпадает с расчетной согласно этой знаменитой формуле. Аналогичная ситуация складывается и с формулой Ш.Кулона взаимодействия электрических зарядов, которая, кроме того, не учитывает, даже, их знаки. Анализируя эти формулы, возникает вопрос, почему в них сила взаимодействия зависит не от вещественных переменных, т.е. от изменений, воздействующих непосредственно на материальное содержимое тел, а от переменных, отражающих пространственно-временные координаты. Ведь цель познания природы направлена на раскрытие особенностей неоднородности распределение материи и процессов, происходящих в ней, которые, прежде всего, характеризуют энергетические и силовые изменения в исследуемой вещественной структуре, а в формулах И.Ньютона и Ш.Кулона они диктуются изменениями расстояний очень далеких от материальной субстанции. В настоящей работе попытаемся ответить, почему это так, и как следует формировать функции, которые должны более адекватно отображать природу.